INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1936

AGRICULTURAL BRANCH

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS,
3 & 4, PORTUGUESE CHURCH STREET,

1937

AGRICULTURAL REPORT.

CONTENTS.

AGRICULTURAL

Recent Planting.

Six acres of new planting at Borbhetta were completed in October and November, 1936, bringing the total nett area under tea at Borbhetta to 74.6 acres, while that at Tocklai remains at 4.4 acres. No further planting of tea is possible at Borbhetta or Tocklai, until the Tea Restriction Act is amended.

The last planted area comprises 144 plots of 100 bushes each, planted in 12 blocks of 12 plots each. The 12 plots in each block are occupied by the 12 different jats of tea to be compared. The blocks are separated by 50 feet of unplanted land, so that shade trees planted on one block will not effect tea on a neighbouring block. Of each pair of blocks one will be planted with Sau trees in late February or early March 1937.

Using the method of complex experiment devised at Rothamsted, 6 plots in each block will be manured annually, while the other 6 remain unmanured. It is proposed to use 60 lbs. nitrogen per acre annually on the manured plots. As well as the important comparison between jats under different conditions, the results will give us an accurate estimate of the effect of shade trees, which can be compared with that of sulphate of ammonia; and, further, we shall be able to determine whether the effect of shade trees is different on unmanured and manured soil.

The 10 acres of tea planted in 1935 were not plucked in 1936. These areas include :—

(1). The Silbhetta block including trials of dark and light leaved jats, each manured in 18 different ways.

The manures include every combination of 100 and 300 lbs. sulphate of ammonia, 0, 50 and 150 lbs. concentrated superphosphate, and 0, 40 and 120 lbs. sulphate of potash per acre.

This tea, planted in October and November 1935, was all cut to 8" in February 1936, it being the intention to prune again at the end of 1936 at a suitable height, weighing the prunings to give an index of the effect of the manures in the first year of growth. The February pruning induced a flush, which was practically all removed by hail in April, just after the manuring.

The young plants had insufficient reserve to make a vigorous second start, and it has been decided not to prune again till the end of 1937.

It is clear from inspection, that there is no great difference between the effects on growth of the different manures used. The effect of the hail, following the drought, was to cause a great number of deaths. The incidence of the deaths afforded some information of interest, since it was influenced by the manuring and by the jat of bush.

Jat.

Light leaf 809 plants died or 11.7%
Dark ,, 698 ,, ,, ,, 10.1%

This difference is statistically significant. The light leaf jat has proved a little more delicate than the dark-leaf jat.

Sulphate of ammonia as manure.

300 lbs. per acre 873 plants died, or 12.6%
100 ,, ,, ,, 724 ,, ,, ,, 10.5%

This difference is significant,and a slight increase in death, is indicated as due to the heavy dose of sulphate of ammonia. That sulphate of ammonia has a depressing effect lasting for about 3 weeks has been proved (see report on Tulsipara experiments on p. 69 of this publication). The manure was forked round the bushes in April, so that its concentration about the roots was high at their time of weakness following hail. Manures were applied just before the hail.

On recently planted tea, the normal delay in manuring till the young plants carry a fair amount of leaf (June or even July) is to be preferred to early manuring.

Concentrated superphosphate as manure.

No superphosphate	...	...	520 *deaths.*
50 lbs. per acre	...	...	542 ,,
150 lbs. per acre	...	...	535 ,,

There is no significant effect from superphosphate on the percentage of deaths.

Sulphate of potash as manure.

No sulphate of potash	...	...	529 deaths.
40 lbs. per acre	...	...	552 ,,
120 lbs. per acre	...	...	516 ,,

There is no significant effect from sulphate of potash on the percentage of deaths.

All the vacancies have been infilled and are now established. The manuring of 1936 will be repeated in 1937. The plants will be unplucked during 1937 and will be pruned at the end of the season to 18″, prunings being weighed to give an index of the effect of the manures on the growth of young tea in its first two years.

Pruning before planting.

On another part of the 1936 planted tea, a trial was made of the effect of removing the green stem (with its leaves), leaving only the red wood, (with its leaves) against planting uncut. This had been reported to give good results in Ceylon.

At Borbhetta the percentage of deaths was equal for both treatments, while the uncut plants are considered to have made more total growth, though the difference is not great.

1932 clearance.

The 5½ acres of tea planted at the end of 1932, was again only occasionally plucked, when labour was available. The price obtained for green leaf barely covers the cost of plucking of low-yielding tea, and the plucking of the whole area regularly would entail an increase in the labour force. Over the good growth of 1936, this area has been cut across at 20″, and plucking of individual plots to establish preliminary yields when all are treated alike will commence in 1937. This area is expected to be suitable for experiment in 2 or 3 years time.

Seasonal Conditions.

The remaining area of 53 acres was regularly plucked, yielding 2,208 mds. green leaf against 2,506 mds. in 1935. The loss is only to a small extent due to difference in manuring. The severe drought covering the end of September 1935 to the end of March 1936 undoubtedly contributed to the loss, but the chief factor is considered to be the hail which swept the whole garden in April, the effect being very severe on about three quarters of the area. The hail stones were not large and little damage to bark resulted, but the first flush (just ready for tipping) was very largely broken or completely stripped. Crop was lost not only while waiting for the growth again to reach the initial heights decided on, but also because the bushes had little reserve left from which to make a second start.

Bushes looked very debilitated till about August, after which they appeared normally vigorous, and yielded normally.

Pruning.

Unpruned tea.

(1). The Tocklai Clearance. Planted 1914.

6 plots pruned in alternate years since 1920.

6 plots pruned annually since 1920.

In 1936 one set of plots was unpruned and the yields were :—

pruned tea ... 15.21 mds. tea per acre.
unpruned tea ... 13.87 ,, ,, ,, ,,

This difference is statistically significant, against the unpruned tea. The unpruned tea has lost crop significantly during the last 5 seasons in which it was unpruned.

When both sets are pruned they yield alike.

It should be noted that, at Tulsipara, the results of similar trials are greatly in favour of unpruned tea for crop (see p. 60 of this volume).

Results of the same difference in treatment may differ under different circumstances.

The experiment at Tulsipara has just completed its 6th year; that at Tocklai has completed its 17th year. In early years, the tea at Tocklai yielded better when unpruned. This may be a reason for the present poorer yield of the unpruned tea at Tocklai, but, no doubt climatic differences also are contributory causes.

(2). The introduction of an unpruned year during the building up of a young bush.

Although it is well to avoid cutting on thick wood near the base of a bush (all the tea left unpruned after collar-pruning at Borbhetta and Tocklai still shows large numbers of unhealed wounds, where cuts were made on two-year-old wood at 6″ or 8″ from the collar up to 19 years ago) it is possible to obtain the benefit of increased growth from leaving young tea unpruned only once, or perhaps twice. The following experiment exemplifies this. The block of Rajghur tea at Borbhetta was planted with one-year-old plants in November, 1924, low centred a year later, and plucked at 30″ in 1926. On part of the clearance, alternate lines were left unpruned in 1927, while the intermediate lines were pruned between 12″ and 15″. Since then pruning has been the same for both, to 18″ for the 1928 season, 20″ for 1929, 22″ for 1930, 23″ for 1931, 24″ for 1932, 24½″ for 1933, 25″ for 1934, 25½″ for 1935 and 26″ for 1936.

Yields in mds. tea per acre have been :—

Year	Annually pruned	Unpruned in 1927 only ; then annually pruned.
1927	3·84	7·60
1928	5·45	5·87
1929	8·51	9·56
1930	9·52	10·62
1931	12·66	13·64
1932	11·75	12·09
1933	13·34	13·97
1934	14·22	14·78
1935	15·08	15·60
1936	12·93	12·86
Total ...	107·30	116·59

Not only was a big gain made in the unpruned year, but the unnecessary removal of leaf and stem from the already small bushes in 1927 had a bad effect for several years. Callus formation over some of the larger wounds made on 2-year-old wood is not even yet complete; but in this case these wounds are high enough in the bush to enable removal if damage occurs, certainly at a loss less than the gain already made.

Although very small, the difference, even in 1933, was still significant (the trials are fifteen times repeated).

Differences in 1934, 1935 and 1936 are not significant, but there is not yet any indication of later loss from leaving unpruned in 1927.

Light pruning.

(*a*). Date of Pruning.

(*b*). Cleaning Out.

Each treatment is 7 times repeated in 7 blocks of 10 plots each. 1935 completed one cycle of pruning at different intervals

(*i.e.*, 3, 4 and 6 prunings in the 6 years). 1936 is the first year of a second similar cycle.

Plot-set	Intervals between prunings.	Cleaned out or not.	Date of last prunings	Mds. tea per acre	
				Average 6 years 1930 to 1935.	1936
1.	2 years	No.	April, 1934 and 1936	9·69	7·29
2.	2 „	Yes	„ „ „	10·91	6·95
3.	2 „	„	June „ „	9·91	6·70
4.	2 „	„	October „ „	11·57	13·64
5.	1½ „	„	Dec. „ May 1936	10·55	6·13
6.	1½ „	„	„ „ July „	11·90	7·49
7.	1 „	No.	„ 1st. 1935	10·32	10·37
8.	1 „	Yes	„ „ „ „	12·30	12·53
9.	1 „	Yes	Jan. 10th. 1936 ...	11·38	11·83
10.	1 „	Yes	Feb. 19th. „ ...	9·33	10·90
			Difference required for significance. ...	0·98	

(*a*). Date of Pruning.

The monthly crops in 1936 are recorded so that the effect of date of pruning on the distribution of the crop over the season may be observed.

All bushes from which yields are recorded below were cleaned out when pruned, and were plucked at 8″ to the janam.

No set of plots was unpruned for the whole of season 1936, but plot set 4, pruned on October 30th illustrates the behaviour of unpruned tea. This yielded very well early in the season, but was passed, after the middle of July, by the tea annually pruned in December.

Plot-sets 2, 3, 5 and 6 also started the season unpruned. It will be observed that up to their respective 1936 pruning dates, for any complete month during which they were plucked yields are alike. It made no difference whether the previous pruning had been in April, June, October or December 1934.

Pruning later than December delays the filling up of the plucking surface, so that later-pruned tea yields less even in November. Although the second flush comes through on practically the same date, it is less in quantity, and following flushes also are less. The earlier the pruning, then, the better.

Any pruning in the growing season puts bushes entirely out of plucking for about 2 months while the initial growth is being made; and after plucking starts, yield is small for months. Any pruning in or near the growing season therefore loses crop badly.

Plot-set	Date of pruning	Mds. tea per acre 1936									
		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
4	October 1934 and October 30th, 1936	0·48	1·42	1·58	1·16	2·17	1·79	2·98	2·07	nil	13·64
8	December 1934 and Dec. 2nd, 1935	nil	0·02	0·45	0·81	2·09	1·91	3·38	2·54	1·33	12·53
9	January 1935 and Jan. 10th, 1936	nil	0·02	0·51	0·68	1·91	1·79	3·21	2·40	1·31	11·83
10	February 1935 and Feb. 19th, 1936	nil	nil	0·17	0·56	1·57	1·61	2·99	2·31	1·16	10·97
2	April 1934 and April 7th, 1936	0·40	1·15	nil	nil	0·34	0·63	1·97	1·74	1·11	6·95
5	December 1934 and May 9th, 1936	0·45	1·46	0·68	nil	nil	0·30	1·19	1·24	0·81	6·13
3	June 1934 and June 25th, 1936	0·41	1·48	1·47	1·10	nil	nil	0·60	0·96	0·69	6·70
6	December 1934 and July 30th, 1936	0·46	1·43	1·47	1·08	2·11	nil	0·03	0·49	0·42	7·49

(*b*). Cleaning Out.

Here we have two sets of plots for comparison.

(1). Annually pruned in December.

	Mds. tea per acre 1936									
	March	April	May	June	July	Aug	Sept.	Oct.	Nov.	Total
Cleaned out	*nil*	0·02	0·45	0·81	2·09	1·91	3·38	2·54	1·33	12·53
Not cleaned out	*nil*	*nil*	0·17	0·56	1·57	1·60	3·00	2·31	1·16	10·37
Loss for not cleaning out	....	....	0·28	0·25	0·52	0·31	0·38	0·23	0·19	2·19
Loss %	....	....	62	31	25	16	11	9	12	....

The percentage of crop lost is heaviest in the early season and falls off as the season progresses. The bushes which have now not been cleaned out for 7 years carry only thin twiggy live wood, and are full of rotting dead wood. In early years loss was heavy only on early teas, crops becoming equal towards the end of the season. End of season crops are now significantly different, and this is ascribed to the increasing diseased state of the bushes not cleaned out.

(2). Pruned at intervals of two years in April.

	Mds. tea per acre, 1936									
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Cleaned out	0·40	0·76	*nil*	*nil*	0·34	0·63	1·97	1·74	1·11	6·95
Not cleaned out	0·49	0·85	*nil*	*nil*	0·49	0·64	2·03	1·75	1·04	7·29

There is no significant difference in crop whether the tea is cleaned out or not. This has always been found to be the case in the pruned year. Tea which has been unpruned and then is pruned on two-year-old wood carries very few banjhi shoots. In the unpruned years differences in favour of cleaning out appear, at Borbhetta, though not at Tulsipara.

(3). Different degrees of cleaning out.

These trials were made as preliminaries to further trials on larger plots which will give sufficient leaf for separate manufacture. The greatest interest attaches, at the present moment, to the effect of cleaning out on quality.

Judging from the appearance of the leaf on the bushes, typical Assam second-flush leaf does not appear unless banjhis at least are removed, while stick pruning produces large-leaved shoots similar to those from cut-back tea. Even this guess about the effect on quality requires proof by manufacturing experiment, while as to differences in quality due to smaller

variations between these extremes, not even a guess can be made at present.

These present trials were made using 72 plots of only 32 bushes each and error proves too high to show, as significant, the effect on crop of small variations, but the results are of sufficient accuracy to show up any large effects.

Plot-set No.	Pruning	Md. tea per acre 1936
1.	Cut-across : nothing cleaned out... ...	10·18
2.	Cut-across : dead wood only removed ...	10·48
3.	Only banjhi shoots removed	11·34
4.	Banjhi shoots and dead wood removed ...	11·38
5.	As (4), but weak or crossing shoots also removed (Normal Tocklai pruning) ...	11·15
6.	Exactly as (5), but in future cleaned out in alternate years only	11·21
7.	Similar to (5) and (6) but only strong shoots left, spaced out to a hand's breadth apart (Common Upper Assam pruning)	10·80
8.	Stick-pruned	8·67
	Difference required for significance ...	0·70

(4). Dead wood and removal of banjhi shoots.

For each of these two comparisons we have two sets of plots to compare.

	Banjhi shoots removed.	Banjhi shoots left in.	Means of 18 plots.
Dead wood removed	11·38	10·48	10·93
Dead wood left in	11·24	10·18	10·76
Means of 18 plots	11·36	10·33	

Between means of 18 plots a difference of 0.50 mds. tea per acre constitutes a significant difference.

The removal of dead wood therefore makes no significant difference in the first year. It has sometimes been suggested

that the exposure of live wood, due to cutting away the dead, produces drying which reduces crop. It is interesting to find that this is not the case. Any damage from the leaving of dead wood would not be expected till wood-rotting fungi attacking the snags have spread into frames, and probably it will be some years before damage from this cause shows up.

The effect of removing banjhi shoots is a very definitely significant gain in crop, much of which is on the early valuable teas.

Crops to mid-July are generally of distinctly higher value than the average of the season, in Assam, at any rate.

On these plots, crops to July 14th were :—

banjhi shoots removed	...	2.30 mds. tea per acre.
no cleaning out	...	1.81 ,, ,, ,, ,,
gain from removal of banjhis	...	0.49 ,, ,, ,, ,,

In 1936, at Borbhetta, early crops were below normal. Probably a greater gain in mds. tea per acre of early crop would be observed in most years.

(5). Heavier cleaning out than removal of banjhis only.

Further removal of live wood, in addition to banjhis, has produced no advantage in crop, at any rate in the first year. It might, of course, produce better quality; but there is at present no evidence on this point.

In the case of the comparison between the "Tocklai" light cleaning out and the removal of banjhis only, we have again 18 plots of each for comparison. Since the removal of dead wood makes no difference, plot-sets 1 and 2 may be considered to have

been treated similarly, while plot-sets 5 and 6 were actually treated identically by the "Tocklai" manner of cleaning out.

		means of 18 plots.
banjhis only removed ...	...	11.34 mds. per acre.
"Tocklai" light cleaning out	...	11.17 ,, ,, ,,
difference	...	0.17 ,, ,, ,,

This difference is negligible compared to the difference required for significance of 0.50 mds. Loss from the further cleaning out therefore is negligible, but no advantage from the additional expenditure has yet been demonstrated. Crops from both treatments were alike to mid-July.

Still further removal of live wood, by the method common in Upper Assam, here described as "spacing out," has produced a still lower crop.

Stick pruning (mean of 9 plots)	...	8.67 mds.
Spacing out (mean of 9 plots) ...	...	10.81 ,,
Light cleaning out (mean of 18 plots)	...	11.17 ,,
Banjhis only removed (mean of 18 plots) ...		11.34 ,,

When comparing a mean of 9 plots with a mean of 18 plots a difference of 0.61 mds. is required for significance. This difference is not reached even comparing the spacing out to the removal of banjhis only, so that no loss even from the heavy cleaning out such as is common in Upper Assam has been demonstrated.

The drastic cleaning out described as stick-pruning however, yielding only 8.67 mds. tea per acre, has very significantly reduced crop, and it may be suspected that more accurate experiment might prove loss even from the spacing out.

The stick-pruning left only one shoot on the end of each branch. One effect of this was to produce a large number of new shoots ("suckers") from low down. There can be little doubt

that the leaf from these must have reduced average quality in 1936. Very strict stick-pruning would have removed all these at the pruning of December 1936. Such removal must entail their regrowth in the following year. All such as filled useful position were therefore left in December 1936.

(6). Effect of delay in cleaning out

Where tea is pruned annually, as it generally is in Assam, the importance of early pruning is established. It increases total crop, and, relatively more greatly, the crop of valuable second flush teas. The rate of pruning is greatly increased if time is not spent on cleaning out. Cleaning out is essential, in Assam, to increase crop, particularly the valuable second flush, while it is strongly suspected that second flush quality will not appear at its best unless banjhi shoots at least are removed.

It is therefore necessary to examine the effect of such delay in cleaning out as is entailed by first cutting across at a rapid rate, and then cleaning out when the cut-across is finished. For this reason, three sets of plots have been pruned as below since 1933.

Pruning	mds. tea per acre			
	1933	1934	1935	1936
1. Pruned and cleaned out in one operation in early December ...	11·83	13·06	12·93	10·76
2. Cut-across on same day as (1): cleaned out 7 weeks later ...	11·56	12·82	12·46	10·52
3. Cut-across on same date as (1); cleaned out 14 weeks later in 1934, 1935 and 1936 ... ... In 1933 cleaned out on March 31st. which is much too late	(9·48)	11·71	11·68	9·93
Difference required for significance	0·25	0·47	0·52	

In each year the loss from 7 weeks delay in cleaning out is of no practical importance, though in 1933 it was statistically just significant. Delay of 14 weeks leads to losses of importance, which are increased as delay is lengthened.

It is considered therefore that it would be good generally to hurry though the cutting across, and clean out afterwards. Observation indicates that cleaning out must be finished before the first flush has started growth in the banjhi shoots which will be removed. That is, cleaning out should be finished by about the first week in March at the latest. The earlier it can be finished the better, but delay in cleaning out is of much less importance than delay in cutting across.

At Borbhetta it costs about 20 per cent. more to prune in two operations instead of one: but at Borbhetta, (and similarly circumstanced gardens) the extra cost is of no importance, since, if it were not so used, there would be no remunerative work for the labour force over a large part of the cold weather.

Trial of collar pruning against medium pruning (18″).

The cutting back was performed in the cold weather 1927/28. Yields in 1936 have been :—

medium pruned	...	11.67 mds. tea per acre.
collar pruned	...	10.42 ,, ,, ,, ,,

The collar pruned tea, in the ninth year after cutting, is still significantly the worse.

In the nine years since cutting, total crops have been,

medium pruned	...	91.0 mds. tea per acre.
collar pruned	...	68.7 ,, ,, ,, ,,
loss from collar pruning	...	22.3 ,, ,, ,, ,,

For a few years after cutting back, the tea which was collar-pruned, carried stouter new shoots of more vigorous appearance than those from the medium pruning. As bushes approached their old size, the effect of the greater stimulus of heavier cutting wore off. Now, the collar-pruned bushes look just as "hide-bound" as the medium pruned bushes. The collar-pruned bushes still have the smaller spread, and have no greater appearance of vigour than the medium pruned bushes.

PLUCKING.

(1). *Difference in crop due to difference in what is left on bush, the leaf taken being the same in all cases.*

Treatment	Plucking system in 1936.	mds. tea per acre	
		1935	1936
1.	4″ initial growth then to janam ...	14·88	13·07
2.	6″ " " " " " ...	13·46	12·16
3.	8″ " " " " " ...	12·17	10·99
4.	4″ " " then a big leaf once only	13·11	12·26
5.	6″ " " " " " " " "	11·99	10·46
6.	8″ " " " " " " " "	11·03	9·69
7.	Plucked at 3 leaves above pruning table then to janam	16·34	13·45
8.	Plucked at 5 leaves above pruning table then to janam	14·08	12·88
9.	Plucked at 4″ to janam till the end of July, them 2 big leaves left	(9·16)	9·65
10.	Plucked at 4″ to janam till the end of July: unplucked during August: then skiffed: plucking resumed when leaf came through	(7·57)	8·20
	Difference required for significance	0·63	0·68

In 1936, the second year of similar treatment, bushes continue to yield more heavily the harder they are plucked. On account of early drought, and more particularly as a result of hail in April, all crops are reduced in 1936 compared to 1935, but there is not yet any indication that yields are reduced in 1936 on account of harder plucking treatment in 1935.

(*a*). Influence of longer initial growth and of leaving a leaf.

Initial height of plucking above pruning level	mds. tea per acre 1936		
	plucked to janam	plucked to leave a big leaf once only.	average
4 inches	13·07	12·26	12·66
6 inches	12·16	10·46	11·31
8 inches	10·99	9·69	10·34
average ...	12·07	10·80	

The loss from leaving a big leaf, once only, is about 1¼ mds. tea per acre, and the loss from leaving an extra two inches of initial growth is about the same. These losses are about the same as in 1935, the first year of the experiment.

The bushes plucked at 4″ to the janam present a marked contrast to those plucked to leave a leaf over 8″, at the end of the season. The latter completely cover the ground, and carry healthy leaf of vigorous appearance. The hard-plucked bushes have spaces between them, and the surfaces carry many leaves attacked by brown blight while some shoots have started to die back. After pruning there is a great difference in the thickness of the wood carried.

So far, however, the pruning removes all the disease, and the thin wood flushes healthily.

It is considered that bushes spared by leaving a leaf look healthier than those on which an extra 2″ of initial growth is left. That is, bushes plucked to a leaf over 4″ look better than bushes plucked at 6″ to the janam, and bushes plucked to leave a leaf over 6″ look better than bushes plucked at 8″ to the janam.

It is unfortunate that these methods of maintaining health by sparing early plucking reduce greatly the crop of tea made in the quality season.

Initial height	Mds. tea per acre to 17th July		
	To janam	To a leaf	Average
4 inches	3·28	3·03	3·15
6 „	2·76	2·30	2·53
8 „	2·08	1·79	1·93
Average ...	2·71	2·37	

The loss from leaving a leaf is about 0.3 mds. of the best tea of the season. The loss from leaving 2″ extra initial growth is about 0.6 mds.

It is not, of course, certain how early quality varies with difference in plucking. This point will be examined in season 1937.

(*b*). Sparing after the second-flush has been taken.

If it is found that early crop is as good when plucked over short growth as over long growth (it might prove even better), and it is also found that hard plucking is too great a strain on the bush, then it will be important to determine whether it is possible to do the necessary sparing so as to lose rains teas of little value, instead of the valuable second flush.

It has been shown (see Annual Report 1931, p. 30) that to skiff during the rains down to the previous plucking level, though it naturally lost crop while the bushes were out of plucking, did nothing to increase or decrease the future bearing capacity of the bush.

In 1935, therefore, trials were made of skiffing to leave respectively one and three leaves over the last plucking level.

The leaving of 3 leaves lost crop heavily after the bushes came back into bearing during that season, while the skiffing over one leaf lost little.

All 3 sets of plots from which results are quoted below yielded exactly equally to the end of July 1935, when plucked at 4″ to the janam. They were again plucked at 4″ to the janam to the end of July in 1936 with the following results :—

Treatment in 1935.	mds. tea per acre to end July 1936.
Plucked throughout season ...	4·54
Plucked to end July, unplucked in August, then skiffed to leave one leaf over previous plucking level	4·79
Plucked to end July unplucked in August then skiffed to leave three big leaves over previous level ...	5.02

These methods of sparing, after taking the valuable part of the crop, therefore had increased the future bearing capacity of the bushes.

It is considered that the leaving of one leaf hardly does sufficient sparing to give the desired increase in second flush crop in the following season, while the leaving of three leaves loses too much of the autumnal crop.

It is objectionable to make even slight changes in treatment after an experiment is started, but it was considered useful to do so in this case; and to confine attention to cases where two leaves are left over the last plucking level, from 1936 onwards.

The two conditions studied must occur on many gardens where, under the restriction scheme, the potential crop exceeds

the quota, while considerations both of labour supply and of quality make it desirable to gather as much as possible of the total crop between mid-May and mid-July rather than during the rains.

It may be desirable during the rains to drop plucking altogether on some areas, and on others merely to reduce the crop of rains teas.

All three sets of plots were plucked at 4″ to the janam to the end of July and then treated as described below.

Date.	Mds. tea per acre, 1936.		
	Crop.	Unplucked August 7th only : on August 14th and in following weeks, plucked to leave 2 big leaves over the plucking level of end July.	Unplucked for whole August then skiffed to leave 2 big leaves.
To end July ...	4·54	4·79*	5·02*
August ...	2·04	1·02	nil.
September	2·64	1·21	0·32
October...	2·69	1·81	1·94
November	1·16	0·82	0·85
Total for season	13·07	9·65	8·29

* Increases due to sparing in season 1935 (see page 18).

In the case where the tea was skiffed over two leaves the loss of crop was heavy. The loss could be reduced to practically nothing during October and November, by skiffing to the original plucking level, but in that case there would be no sparing of the bushes to increase the following second flush crop. It remains to be seen whether the effect of the sparing now being tried proves progressive, and sufficient in amount to justify this method for use in practice.

The other method, raising the plucking level in the rains by 2 leaves, but maintaining regular plucking, reduces the August-September crop almost exactly by half; and, though it reduces also autumnal crops, might prove useful compared to sparing early in the season. Bushes look very green and healthy at the end of the season. The crop distribution may be compared to what is obtained from plucking from the start at 8″ and then leaving a leaf once only.

	Mds. tea per acre, 1936.	
	8″ then one leaf.	4″ to janam till end July then 2 leaves left.
To end June	1·01	2·30
July	1·76	2·49
August ...	1·43	1·02
September ...	2·02	1·21
October ...	2·45	1·81
November ...	1·02	0·82
Total ...	9·69	9·65

Total crops are equal but the sparing in the rains looks the more likely to give better average quality and to prove more convenient with regard to labour requirements. October crops in Assam are seldom very much better valued than rains teas. The resulting quality will be studied in 1937.

(*c*). Plucking to a given number of leaves instead of to a given length of new wood.

It had been hoped that plucking to a number of leaves might yield crops subject to less seasonal variation than plucking over a given measure.

Results of 1935 and 1936 do not offer much hope that this will prove to be the case.

	Mds. tea per acre		Difference.
	1935.	1936.	
At 4″ to janam ...	14·85	13·07	1·78
To leave 3 leaves ...	16·34	13·45	2·89
6″ to janam ...	13·46	12·16	1.30
To leave 5 leaves ...	14·08	12·88	1·20

The plucking to leave 3 leaves only is, of course, extremely severe. Bushes looked very miserable in June, after drought and hail; and though they recovered somewhat, later in the season, the appearance of the bushes was anything but desirable, and it will be very interesting to see how long they can stand the treatment. None of the 700 bushes subjected to this treatment has yet reached the point of death. In June some looked near to it, but this might have been an effect of the very bad early season.

(2). *Differences due to what is taken from the bush, all being plucked at 8″ with breaking back to janam, weekly.*

Style of plucking	Plucking Orders	Mds. tea per acre	
		1935	1936
1. Superfine ...	All shoots of 2 and a bud. All shoots of 1 and a bud as far as possible. Single banjhis ...	8·10	6·43
2. Fine ...	Very large shoots of 1 and a bud. All shoots of 2 and a bud. Single banjhis	7·90	6·45
3. Medium ...	No shoots of 1 and a bud. All shoots of 2 and a bud. Double banjhis	8·20	6·72
4. Coarse ...	Everything taken down to the janam, except that no shoots of 1 and a bud are taken ...	9·86	7·92
5. Very Coarse	Nothing finer than shoots of 3 and a bud and double banjhis ...	11·54	9·07
	Difference required for significance	0·50	0·46

Differences in crop between the superfine, fine and medium styles are not significant. That the taking of shoots of 1 and a bud does not reduce crop is, at least partly, accounted for by the fact that no breaking back is necessary on these bushes, while where shoots of one and a bud are not taken, many shoots of three and a bud appear in a week's time, and the third leaf is thrown on the ground. No difference in health or vigour of the bushes is yet noticeable among these styles of plucking.

No manufacturing experiments were made on these plots in 1936. The differences shown in 1935 are reported in the Annual Report for 1935, p. 21.

(3). *Differences due to breaking back and to leaving banjhi shoots on bush.*

All plucked finely over 8″ initial growth :—

	Mds. tea per acre.	
	1935.	1936.
No breaking back at all ...	7.95	6.74
Broken back to janam	7.90	6.45
Broken back to original tipping level	8.00	6.51
Banjhi shoots left on bush till they come through	6.31	5.48
Difference required for significance	0.50	0.46

Whether bushes are broken back to the tipping level, to the janam, or not at all, has not yet made any significant difference to crop. The bushes broken back to tipping level look very debilitated at the end of the season, distinctly worse than those broken back to the janam only, which rise about 2½ inches in the course of the season.

The bushes not broken back get very leafy, and though they carry uneven surfaces, making supervision less easy, plucking is rapid since no time is wasted in breaking back; and the bushes finish the season looking very healthy indeed. Reports in 1935 indicated that "quality" was slightly better, and "strength"

slightly less where bushes were not broken back, and the strength was preferred in London.

The leaving of banjhi shoots on the bush reduces crop greatly, without improving quality.

Cultivation.

1. The 19 single-plot trials, started in 1922, continue to give results generally similar to those of previous years. Although the single-plot design allows no estimate of the error to which results are liable, comparison, between all pairs of treatments, indicates clearly enough that suppression of weeds is the factor of main importance in cultivation, while the breaking up or stirring of the soil has little or no effect, whether applied to the surface, or to increasing depths. On this tea, averaging about 11 mds. per acre, 5 to 6 light hoes per annum give maximum efficiency: any increase in number of hoeings gives no greater good effect, but to reduce the number to 4 only, allows such jungle growth that crop is reduced greatly. Scraping the surface (cheeling) gives efficiency equal to that of light hoeing. The plots merely scraped (cheeled) to a depth of much less than an inch, not deep-hoed or disturbed in any way, but carrying bushes as good as are to be seen on any plots however "well-cultivated", now provide a demonstration very striking to agriculturists imbued with text-book ideas on the advantages of breaking up the soil. During the cold-weather, the soil sets as hard as a road. Prunings rot on the surface and appear not to suffer in efficiency as manure compared to buried prunings. The soluble manures used are merely broadcast and allowed to soak in.

A perennial shrub like tea does not need a seed bed. The seeds of weeds, on the contrary, germinate and grow much better on a loosened tilth. The close occupation of the surface soil allowed to the roots of tea, when undisturbed by implements, also greatly hinders the growth of weeds. At Borbhetta, where the light hoeing is closely supervised, hoeing and cheeling are of equal efficiency. This is demonstrated on another set of plots (with 5 replications), over the last 5 years.

	When under same treatment, all hoed.		When under different treatment				
	1930	1931	1932	1933	1934	1935	1936
5. rounds cheeling (scraping) in 1932 and following years ...	9·71	10·81	8·63	10·78	10·76	10·58	10·54
5. rounds light hoeing in 1932 and following years	9·73	10·79	8·43	10·48	10·58	10·33	10·11

The apparent difference in favour of cheeling is not statistically significant, but it is clear that no loss has occurred from failure to disturb the soil for 6 years. Neither set of plots gets any deep hoe : both were deep-hoed in 1930 and 1931.

For the benefit of those not familiar with tea in Assam, it may be explained that light-hoeing cuts a sod about $9'' \times 12''$ and from 2 to perhaps 3 inches deep, and turns it over on to the bare space left by the sod last cut. On gardens, in practice, the cut sod is frequently turned over on to an uncut space, and this practice is very difficult to check. Possibly for this reason cheeling often appears to be the more efficient in commercial practice. The "cheeling" merely scrapes off surface weeds, into heaps, taking with them very little soil indeed.

The plot receiving the very deep hoe (18″), annually, generally gives crops equal to those from plots "deep-hoed" to about 7″ only. There is no loss from the very deep hoeing, though there is no gain.

In 1936 the very deep hoed plot lost crop after the serious drought of the previous "cold weather", compared to the otherwise similar plot receiving the ordinary deep hoe.

	Average 1930 to 1934	1935	1936
Plot 93. ordinary deep hoe (7″)	12·4	12·8	11·0
Plot 94. 18″ deep hoe	12·4	12·9	10·3

The deeply cultivated plot also lost crop in 1928 after another drought in the previous cold weather, but in 1928 the bad effect of the deeper hoeing was greater.

	1926	1927	*1928*	1929	1930	1931	1932
Plot 93. ordinary deep hoe ...	10·1	12·2	*11·7*	11·4	11·7	12·4	10·6
Plot 94. 18″ deep hoe	9·9	12·3	*10·4*	10·5	11·3	12·7	10·7

In 1936 the very deeply hoed plots made up some of the loss later in the season, but to the end of June the yellow unhealthy appearance of the bushes was marked, and they clearly had suffered more greatly from water shortage.

	mds. tea per acre to end June, 1936.
Plots 90 and 91, no deep hoe ...	1.52
Plot 93, ordinary deep hoe ...	1.16
Plot 94, 18″ deep hoe	0.78

The deeper the hoeing the worse is the suffering after drought.

2. A further set of plots compares the effect of greatly reduced cultivation with that of normal "good cultivation" among tea giving such cover as itself effectually reduces weed growth. It must be emphasised that similar results would not be obtained among poorer tea giving less cover.

	Plot-set	1936 Cultivation	Mds. tea per acre				
			1932	1933	1934	1935	1936
Normal cultivation A deep hoe and 6 light hoes	1.	Deep hoe the day after pruning, to bury prunings as is usual.	15·5	18·6	19·4	21·2	20·3
	2.	Deep hoe the day before pruning leaving prunings unburied to rot on the surface ...	15·1	17·8	18·4	20·9	19·7
Reduced cultivation	3.	Hand weeded only. 4 times per season ...	15·8	19·5	21·0	21·1	19·9
	4.	As 3, but with deep hoe to bury prunings in addition ...	14·7	17·6	19·2	20·0	19·5
	5.	4 light hoes only. No deep hoe ...	15·0	16·8	18·1	19·2	18·5
	6.	Sickled only. Four times per season. No form of cultivation whatever ...	14·1	16·6	18·1	18·6	17·0
Difference required for significance			0·67	1·14	1·11	1·51	1·22

Among the first three types of cultivation, all of which suppress weeds completely, there is no difference in effect which is of any significance. The hand-weeding alone, with the soil never disturbed at all, does at least as well as the thorough cultivation, with burial of prunings, of plot-set 1.

For three years, the hand weeding did significantly better without a deep hoe than with it, but over the last two years the difference has not been significant.

Reduction of cultivation to 4 light hoes only, does allow some jungle growth, and crops are significantly reduced, though they are still very good indeed.

The most interesting plots perhaps are those which are only sickled. Here the soil remains completely undisturbed. No

forking around the bushes is given, and manures are simply broadcast and allowed to soak in. Weeds are always present, but grow very little. Crop is significantly reduced below that produced by more complete suppression of weeds but is so high that bushes can be suffering very little if at all, from the the complete absence of any disturbance of the soil.

Hand-weeding.

On the evidence to-day, hand-weeding appears to be very efficient. Other types of cultivation, using any form of implement, allow the establishment of certain types of weed, while hand-weeding removes all. Whether the land eventually will suffer from entire absence of any disturbance remains to be seen, but at present the evidence is against such a supposition.

The objection to hand-weeding is its initial cost among normal tea not providing close cover.

Cost is difficult to estimate on small plots.

An area of 3 acres at Borbhetta has therefore been devoted to hand weeding merely to determine its cost on an area planted 5′ × 5′ triangular, yielding about 10 mds. tea per acre, and providing only light cover.

The monthly round as practised generally in Ceylon was found impracticable in the first year at any rate. Land soon becomes fairly thickly covered by weeds too small to grasp and uproot. Intervals of about 2 months or a little more appear to be close enough and the weeds are then more easily uprooted.

On this particular area, one-twentieth of an acre was found to be a full day's task for an active woman. Three rounds of this work kept the area quite clean and cost about as much as six light hoes. Next year, on the cleaned land, cost may prove less.

In 1936 hand-weeding followed a good deep hoe and a light hoe. No deep hoe or light hoe will be given in 1937. The land in December was hard and smooth, and it is thought that weeds will not establish themselves easily.

Manuring in replacement of cultivation.

Our hypothesis is that weeds reduce crop mainly by reduction of formation of nitrates in the soil they occupy, so that weedy tea, even on a rich soil, is underfed. Among the single plots first referred to are two kept at equal cost, as nearly as can be estimated.

The one gets a deep hoe, and 6 light hoes, and 200 lbs. sulphate of ammonia annually. The other gets a deep hoe, one light hoe, and 400 lbs. sulphate of ammonia annually. The deep hoe probably has no effect in either direction on the former plot, and does a little harm by encouraging weeds on the latter; but this was not appreciated when the trial was started, and it is not desirable to change systems which have been under comparison for 17 years.

Up till 1927 the cultivation gave a better return than the manuring; but for the last few years the manuring has scored heavily.

The more heavily manured bushes now afford such thick cover that few weeds can grow.

	Plot 88 One light hoe and 400 lbs. sulphate of ammonia per acre annually.	Plot 89 Six light hoes and 200 lbs. sulphate of ammonia per acre annually
925 to 1929, average ...	7·7	10·0
1930 to 1934, average ...	14·7	11·4
1935 ...	16·0	11·4
1936 ...	15·1	10·3

The difference of over 4½ mds. is more than usually obtained for a difference of 200 lbs. sulphate of ammonia. The excess is probably to be ascribed to the saving of nitrogen in early years when crops were reduced by the presence of weeds.

MANURING.

Nitrogenous Manures.

Different quantities of nitrogen per acre annually.

1. Soluble artificials in single and divided doses.

The nitrogen is given in rotation, 2 years as sulphate of ammonia, then 1 year as calcium cyanamide. This has the effect of maintaining soil acidity about constant. Where sulphate of ammonia is used continuously it increases soil acidity greatly, which causes a greater increase in crop than that due to nitrogen alone, and it is the effect of nitrogen which we desire to measure in this case.

The manure was applied in 1930, for the first time, to tea planted in 1922 and not previously manured.

Results have been :—

Plot-set	Total lbs. nitrogen annually	How applied	mds. tea per acre						Average for different total dressing	Gain in 7 years	Gain per 40 lbs. nitrogen annually
			1930	1931	mean 1932 1933	mean 1934 1935	1936	Total in 7 years			
1	*nil*	*nil*	7·5	8·2	6·9	6·7	6·3	49·1	49·1	....	....
2	40	1 dose in March	9·6	10·3	10·0	10·8	9·6	71·0	71·5	22·4	22
3	40	20 lbs. „ March .... / 20 „ „ June	9·1	10·9	10·4	10·8	9·7	72·0			
4	80	1 dose „ March	11·0	13·4	14·0	15·4	14·1	97·3	95·9	46·8	23
5	80	40 lbs. „ March .... / 40 „ „ May	10·9	13·5	13·7	14·8	13·8	95·2			
6	80	40 „ „ March .... / 40 „ „ June	10·9	13·2	13·6	14·7	13·5	94·0			
7	80	40 „ „ March .... / 40 „ „ July	11·1	13·4	13·8	15·4	14·2	97·2			
8	120	1 dose „ March	12·4	15·6	15·8	17·6	16·0	110·7	112·2	63·1	21
9	120	60 lbs. „ March .... / 60 „ „ June	12·4	16·1	16·6	18·3	16·9	115·2			
10	120	40 „ „ March .... / 40 „ „ May .... / 40 „ „ July	11·3	14·8	15·8	18·0	16·4	110·7			
Difference required for significance			0·55	0·65	0·76	0·80	0·82	....	....	....	....

It will be observed that the total gains per 40 lbs. nitrogen are not greatly different : that is, the gain from manuring is not far from proportional to the quantity of nitrogen applied. The average over the first seven years is 3.2 mds. tea annually for 40 lbs. nitrogen annually.

It will be observed that such great gains are not obtained in the first year of application. Gains at first are small, but the effect of annual manuring is cumulative.

Total annual nitrogen per acre.	Increased crop in mds. tea per acre				
	1930	1931	mean 1932 1933	mean 1934 1935	1936
40 lbs.	1·83	2·42	3·29	4·11	3.30
80 lbs.	3·46	5·20	6·86	8·41	7·58
120 lbs.	4·69	7·31	9·17	11·32	10·10
Average per 40 lbs. nitrogen	1·66	2·49	3·22	3·98	3·50

Response to manuring varies seasonally, but by about the fifth year of continuous manuring (with an efficient form of nitrogen) the gain usually settles down to between 3½ and 4 mds. tea per acre annually per 40 lbs. nitrogen.

It will be observed from the table that gains are practically the same whether the total dressing is applied in single or divided doses, or whenever the later dressings are applied. Previous experiments showed that the date of any single dressing made no difference to total crop increase. Manures may be applied whenever convenient.

Application in two, instead of one dose, makes a difference to the time at which crop is produced in early years; but, in later

years of continuous manuring, so much of the total effect is due to the dressings of previous years, that it makes little difference whether manures are applied in one dose or in two, even to the distribution of the crop. For example with a total of 80 lbs. nitrogen per acre.

	mds. tea per acre 1936.							
	to end May	June	July	Aug.	Sept.	Oct.	Nov.	Total.
40 lbs. March 15th ... / 40 lbs. July 15th ...	0·97	0·95	2·10	2·59	3·57	2·52	1·36	14·25
80 lbs. March 15th ...	1·04	1·05	2·18	2·37	3·53	2·49	1·45	14·11

or with a total of 40 lbs. nitrogen.

	to end May	June	July	Aug.	Sept.	Oct.	Nov.	Total.
20 lbs. March 15th ... / 20 lbs. June 15th ...	0·54	0·66	1·56	1·64	2·44	1·81	1·14	9·79
40 lbs. March 15th ...	0·44	0·86	1·36	1·50	2·50	1·82	1·10	9·58

A point, not as generally appreciated as it should be, is that not only is the crop of tea per acre increased by manuring with artificials, but the weight of prunings per acre also.

In 1936 the prunings were weighed, just after cutting, from 7 of these sets of plots (that is from a total of 49 plots), with the following results.

Manuring total lbs. nitrogen annually per acre over 7 years.	Green weights of prunings in tons per acre		Mean
nil	2·86		2·86
	Single dose in March	Divided doses March and June	
40	3·91	4·31	4·10
80	5·28	5·53	5·41
120	6·32	6·41	6·35
Difference required for significance ...	0·99	0·99	0·70

There was no significant difference in composition of the prunings with different manuring.

All averaged, within sampling error,—

organic matter	... ...	35 %
ash	... ...	2.2 %
moisture	... ...	63 %
nitrogen	... ...	0.66%

Roughly, each extra 40 lbs. of artificial nitrogen as manure means an additional 1.2 tons per acre of prunings, (containing 0.4 tons of dry organic matter) annually. This is as much organic matter as is contained in about 4 tons of average cattle manure or "humus compost."

The continual application of this form of organic matter, much of which is not readily broken down in a soil well occupied by tea roots, has its effect in maintaining and increasing the organic matter content of the soil, as is shown by the following determinations made on soil samples taken in November 1936, before pruning in December. No undecomposed prunings were present at the time of sampling.

lbs. artificial nitrogen annually as manure over 7 years.	Loss on ignition of dry soil per cent (organic matter)	Nitrogen in dry soil per cent.
0	2·80	0·094
40	2·93	0·096
80	3·09	0·101
120	3·10	0·104
Difference required for significance	...	0·005

The supposition, very commonly expressed, that the use of artificial nitrogen, on tea, "exhausts" the soil, is the reverse of the truth.

2. Cattle Manure.

Manure at 5, 10 and 20 tons per acre was applied to plot-sets 1, 2 and 3 respectively in April 1931, the fourth plot-set being left unmanured. In 1932 all plots were unmanured to observe residual effects. In 1933, 1934, 1935 and 1936 manure applications at 5 and 10 tons per acre respectively were resumed on plot-sets 1 and 2. Plot-set 3 was not manured again, it being desirable to observe the time during which the effect of a single big dressing of cattle manure lasted. The following results have been obtained.

plot-set	Manure tons per acre			Mds. tea per acre							
	1931	1932	1933 to 1936 annually	1931	1932	1933	1934	1935	1936	Total 6 years	Total gain due to manure
1.	5	0	5	9·57	10·32	10·57	10·33	10·78	9·78	61·25	10·87
2.	10	0	10	10·10	10·58	11·64	12·85	12·79	11·82	69·78	19·39
3.	20	0	0	11·20	11·66	10·58	9·30	8·33	7·11	58·18	7·79
4.	0	0	0	9·12	9·47	8·96	7·67	8·05	7·02	50·39	...
Difference required for significance				0·54	0·59	0·70	0·64	0·95	0·49	...	...

It will be observed that the gain in crop from 10 tons cattle manure annually is about double the gain from 5 tons annually. As with the soluble artificials, gain is roughly proportional to the quantity of manure applied.

Here also the effect of continuous manuring is cumulative, being small in the early years, and settling down in later years to roughly constant annual increases for the same annual dose.

Tons manure per acre	Gain in mds. tea per acre					
	1931	1932 residual	1933	1934	1935	1936
5	0·45	0·76	1·61	2·66	2·73	2·76
10	0·98	1·11	2·68	5·08	4·74	4·80

These gains are about half what is obtained from the same quantity of nitrogen as soluble artificial. The 5-ton dressing averages about 60 lbs nitrogen.

It will be observed that the seasonal slump in crop on these plots in 1936, following drought, is as bad as on any artificially manured plots. Hail was only slight on this area.

The single big dressing of 20 tons per acre gave marked effect over four following years, but has been without further residual effect over the last two years.

	Gain over no manure in mds. tea per acre					
	1931	1932	1933	1934	1935	1936
20 tons cattle manure in April 1931, no further manuring	2·08	2·19	1·62	1·63	0·28	0·09

There is no "permanent effect" such as is sometimes claimed for bulk manures of this nature.

Different Forms of Nitrogen.

The results already quoted, from soluble artificials and cattle manure respectively, illustrate the fact that it is not enough to know how much total nitrogen is applied as manure, but something must be known also of the efficiency of each manure per unit of nitrogen.

Two main factors regulate the efficiency per unit of nitrogen. Firstly, a plant can take its food only in soluble form and any nitrogen supplied, which does not become soluble, is without effect as manure. This accounts for the low efficiency of cattle manure. Some of its nitrogen compounds are so resistant to decomposition that they remain unaltered in the soil. These resistant compounds increase the organic matter content in the soil. This under certain circumstances may prove to be an advantage. It is impossible to devise an experiment which will separate the effect of the organic matter in a manure from the effect of its content of nitrogen. All that can be done is to measure the sum of the two effects, and all that can be said is that the effect of available nitrogen on tea is so great that it much outweighs any advantage there may be from undecomposed organic matter left in the soil. No evidence of any advantage from organic matter is obtained at Borbhetta, Tulsipara or Halem where experiments on the subject are in progress. This may be because the more efficient artificials produce heavier weights of prunings, and so indirectly maintain or increase the organic matter content of the soil.

That being so, it is a matter only of academic interest, to determine whether or no there is any advantage from a high organic matter content in the soil : but information on this point will be obtained from the experiment described on page 39, which includes plots from which prunings are removed.

Secondly, all manures contain substances other than nitrogen and some of these substances, when sufficient has accumulated in the soil, show "secondary effects" on the physical condition of the soil. Sulphate of ammonia, for example, increases the acidity; and long continued application increases soil acidity so

greatly that it may become too high for many crops. In the case of tea, this increased acidity, so far, has proved a great advantage.

Nitrate of soda, on the other hand leaves a residue of soda in the soil. Its nitrogen is very highly efficient, but the soda, after a few years of continuous application, ruins tilth. Calcium cyanamide leaves a residue of lime. A normal moderate dressing of 2 cwts. is, in respect of lime, equivalent to a dressing of 2 cwts. of commercial slaked lime. The effect of a few such dressings, on soil acidity, is negligible, but very long continued regular use must render a soil unfit for tea.

Experiment 1.

60 lbs. nitrogen annually since 1933.

Manure applied annually.	Mds. tea per acre				Total in 4 years.	Increase over 4 years	Annual cost of manuring at present prices.
	1933	1934	1935	1936			
							Rs. as.
No manure ...	9·12	6·58	6·21	6·00	28·91	...	*nil*
Organic manures.							
Oilcake (rape)	11·12	10·18	10·33	10·49	42·21	13·21	28—0
Blood meal ...	11·38	10·96	10·67	11·07	44·08	16·17	48–11
Horn meal ...	11·59	11·09	11·45	11·27	45·40	16·49	43–12
Soluble artificials.							
Nitrate of soda	11·88	10·89	11·01	9·86	43·64	14·73	37—2
Calcium cyanamide ...	12·13	11·24	11·30	11·34	46·01	17·10	28—1
Sulphate of ammonia ...	12·32	11·62	12·48	12·24	48·66	19·75	27—1
Difference required for significance ...	0·62	0·64	0·62	0·66			

Oilcake has yielded significantly less than the average in each year. This can be ascribed only to the relative insolubility of some of its nitrogen compounds. There is no indication of any loss of tilth of the soil.

Blood meal, horn meal, calcium cyanamide, and nitrate of soda were giving increased crops which were equal within experimental error up to the end of 1935.

In 1936 calcium cyanamide still yields normally; not enough lime has yet been added to the soil to reduce tea crop.

The crops from the nitrate of soda plots have suddenly slumped in 1936 compared to 1935 : this can be ascribed to the loss of tilth of the soil after an addition totalling 1,550 lbs. of nitrate of soda per acre. The trouble is not due to decreased soil acidity, which is higher on these plots than on those receiving cyanamide.

Sulphate of ammonia, in 1935 and 1936, has yielded significantly better than any other manure, and this is probably to be ascribed to the greatly increased acidity of the soil. This relative efficiency is also found on a set of plots on the other side of Borbhetta on stiffer soil (next reported). We have not yet results from similar trials on other soils, but against no manure or against cattle manure, sulphate of ammonia is doing very well in several places. Sulphate of ammonia is the cheapest of all forms of nitrogen, and we must regard it, on the evidence, as the manure generally most suitable for tea, so long as its present low price is maintained.

Experiment 2.

30 lbs. nitrogen per acre annually 1920 to 1931 and 80 lbs. nitrogen per acre 1932 to 1936, except that no manure was applied in 1921, or in 1933 when the tea was cut-back.

Yields are still small after the heavy cutting, and in 1936 are reduced by the effects of hail, which was bad over this area.

	Mds. tea per acre			
	1935	1936	Total in 2 years	Gain over no manure
No manure	5·01	5·01	10·02	...
Sinews and hide ...	6·50	6·92	13·42	3·40
Nitrate of soda ...	8·58	6·73	15·31	5·31
Oilcake (rape)... ...	9·06	9·49	19·15	9·13
Green cuttings of boga medeloa	10·18	9·73	19·91	9·89
Sulphate of ammonia ...	11·22	10·83	22·05	12·03
Difference required for significance for odds of 19 to 1	1·23	1·17	2·33	2·33

The sinews and hide have spoilt the tilth of the soil to some extent. This effect is ascribed to the effect of gelatinous compounds, acting as protective colloids. The main cause of the inefficiency of this "slow-acting" material must be assumed to be the insoluble nature of its nitrogen compounds, even 17 years after the first application.

Nitrate of soda did very well at first. The tea manured continuously with it is now in very bad condition, the soil being now very sticky and compacted.

Oilcake and boga medeloa cuttings behave alike : they are quite efficient, but less so than the sulphate of ammonia.

The marked superiority of the sulphate of ammonia must be ascribed mainly to the increase in soil acidity which it has produced. The plots to which it has been applied have been shown by physical tests to be in more friable condition than any of the other plots.

Effect of prunings from annually pruned tea as manure.

Here four treatments are compared :—

1. Prunings buried with deep hoe in December. No manure.

2. Prunings removed before deep hoe in December. No manure.

3. Prunings buried with deep hoe in December. Manure mixture supplying 40 lbs. nitrogen, 20 lbs. phosphoric acid and 20 lbs. potash per acre broadcast in March.

4. Prunings removed before deep hoe in December. Manure mixture as for 3.

1936 was the second year of similar treatment.

	Mds. tea per acre, 1936		
	Prunings buried	Prunings removed	Mean
With artificial ...	10·36	8·88	9·62
Without ,, ...	7·78	6·35	7·06
Mean	9·07	7·61	...

Difference between means required for significance = 0.48 mds.

The loss due to failure to bury prunings of 1.46 mds. tea per acre is therefore highly significant.

It will be observed that the gain from burial of prunings is the same whether an artificial is used with them or not. They do not need additional available nitrogen to bring them into action.

The sulphate of ammonia also gives, so far, just as big an effect in the absence of prunings (2.53 mds. gain) as in the presence of prunings (2.58 mds. gain). The plots from which prunings are removed are completely deprived of organic matter. Not only prunings but fallen leaves also are picked up, and no weeds are allowed to grow. It will be very interesting, in future years, to see whether the sulphate of ammonia continues to act as well on soils receiving no organic matter.

The prunings are weighed, sampled, and analysed annually.

The prunings, like other such "bulk manures", are inefficient per unit of nitrogen.

	Total nitrogen applied in 2 years	Gain in mds. tea per acre			Mds. tea per 10 lbs. of nitrogen
		1935	1936	Total	
Prunings ...	120	0·88	1·46	2·34	0·19
Sulphate of ammonia	80	2·41	2·56	4·97	0·62

Trial of Tea-waste as Manure.

Manures were applied on June 19th, 1935.

The actual quantities of nitrogen per acre applied were :

as sulphate of ammonia ... 30 lbs.
as 7½ mds. tea waste ... 22.7 ,,
as 15 ,, ,, ,, ... 45·4 ,,

As reported last year, the tea waste had shown no effect in increasing crop up to the end of 1935, although the sulphate of ammonia had done so.

In 1936, yields in mds. tea per acre have been :—

	Mds. tea-waste per acre			Means of 18 plots
	0	7½	15	
With sulphate of ammonia ...	6·98	6·83	7·26	7·01
Without ,, ,, ,, ...	6·51	6·54	6·51	6·52
Means of 12 plots ...	6·74	6·69	6·89	...

Between means of 18 plots, 0.22 mds. per acre constitutes a significant difference. The residual effect in 1936 of the small

dose of sulphate of ammonia applied in 1935 therefore is significant. Between means of 12 plots, a difference of 0.27 mds. would have constituted a significant difference. No effect from the tea-waste therefore has been found. The material used was nearly all tea fluff, which is mainly leaf hairs. Tea waste consisting mainly of leaf and stalk might prove more efficient.

Trials of bulk organic manures against sulphate of ammonia.

1. "Indore" Compost.

A compost made by the "Indore" method from rice straw, using cattle manure and urine-soaked earth from the floor of a cowshed as the starter: applied after 3 months' fermentation, with periodical turning, in a heap.

2. Unfermented materials for Indore Compost.

The materials used for making the Indore compost applied direct to the soil.

The Indore compost loses some nitrogen and much organic matter during fermentation.

	Original composition of heap when made in May.	Final composition of heap when ready in August	Loss per cent
Total dry matter ...	3518 lbs.	2883 lbs.	18
Total ash	2105 „	2083 „	—
Total organic matter ...	1325 „	799 „	39
Total nitrogen ...	30·1 „	24·5 „	18

This trial No. 2 was designed to test a mixture of materials similar to those in the original heap, providing the same nitrogen as in the made compost but with a large excess of unfermented organic matter.

3. "Adco" Compost.

This also used rice straw, but the starter was the patent Adco mixture containing calcium cyanamide, sulphate of potash and a mineral phosphate. It was fermented in a heap, without turning, for the same time as the Indore compost. The straw was not as completely broken down. Since very heavy rain fell (7.62 inches in 3 days) immediately the heaps were made in the open, much of the soluble cyanamide must have been lost, before the reaction could start and reduce the straw to spongy condition. In this case the loss of nitrogen in fermentation was 40 per cent.

The alternative of making the heaps under cover entails heavy costs for watering, and such deluges as these heaps happened to receive are rare.

4. Unfermented "Dacca" Compost.

For this, cuttings 18″ long of the purple-flowered shrub common on grazing grounds, known in Assamese as *Phutuka*, were used. It is a species of Melastoma. The restriction to one species reduces sampling errors, which are still unavoidably very high. The leaf contained 1.1% nitrogen and the stem only 0.3% nitrogen, and to take samples fairly representing the average ratio of leaf to stem presents a difficulty not altogether surmounted by averaging from many independent samples.

"Nicifos" containing soluble phosphoric acid, and nitrogen in the form of ammonia was used as starter, together with some cattle manure to act as an absorbent. The very open brushwood otherwise could not hold the soluble salt used as a starter. The ratio used was :—

		Containing per cent.	
		Nitrogen	Dry organic matter
Sundried phutuka cuttings	60 lbs.	0·626	56
Cattle manure	30 ,,	0·440	11·5
Nicifos	1 lb.	16·6	0

The *phutuka* was cut and left to dry for 3 days before carrying to the sampling ground near the plots. This was to save carriage costs, and to produce a material not rapidly altering in composition by drying at the time of sampling and of weighing out for application.

The quantities for one plot were weighed out and applied direct broadcast over the soil.

Similar quantities were then weighed out on to a heap, in layers first of *phutuka* cuttings, then of cattle manure, over which the nicifos was sprinkled. Between applications to the remaining 6 plots, similar applications were made to the heap. The heap therefore contained the same materials in the same quantities as were applied to the seven plots.

5. Fermented "Dacca" Compost.

The heap above described has been kept moist, and when sufficiently broken down, it will be weighed, and one-seventh of the total quantity applied to each of the 7 plots to be used for its trial. In this case then we measure directly the effect of fermentation, losses of nitrogen counting against the compost.

6. Cattle Manure.

This was "made" by the common garden method, of collecting wherever available and throwing into a covered pit.

7. Sulphate of ammonia for comparison.

8. No manure.

Quantities applied were such as would have supplied 80 lbs. nitrogen on the basis of the preliminary analysis; but sampling is very difficult, and the amount of drying or wetting of materials lying in the open since analysis had to be guessed.

Averages of 6 successive samples taken as the manuring proceeded, give very fairly accurate estimates of what was actually applied.

These are :—

Plot-set	Manure applied	lbs. per acre		
		Total weight of material	Containing nitrogen	lbs. dry organic matter
1.	Fermented Indore compost ...	20145	79·0	2397
2.	Unfermented Indore compost ...	14490	74·4	4795
3.	Adco compost	19320	76·1	2713
4.	Unfermented Dacca compost ...	12558	92·8	5108
5.	Fermented Dacca compost ...	not yet applied		
6.	Cattle manure	20770	81·2	2721
7.	Sulphate of ammonia (a little wet)	400	79·6	*nil*

Quantities of nitrogen per acre are not as equal as was intended, but we know that, within these limits at any rate, the effect will be proportional to the quantity of nitrogen applied, and therefore we shall obtain just estimates of the efficiency of each material per unit of nitrogen.

The manures (other than fermented Dacca compost) were applied between 21st and 25th September. There was not the slightest indication of increase of crop, from any treatment, up to October 10th, but on October 17th, crops from the sulphate of ammonia plots increased over unmanured plots.

Yields from October 17th to November 28th (when plucking ceased) have been :—

Plot-set	Manure	Total of seven weekly pluckings Mds. tea per acre	
1.	Fermented Indore compost ...	1·72	
2.	Unfermented Indore compost ...	1·70	
3.	Adco compost	1·68	
4.	Unfermented Dacca compost ...	1·95	
5.	Cattle manure	1·73	
6.	Sulphate of ammonia	2·08	
7.	No manure	1·64	mean
8.	No manure (Dacca compost to be applied later)	1·71	1·68
	Difference required for significance ...	0·14	

None of the treatments yet show any significant increase in crop over no manure, except :—

Sulphate of ammonia : increase ... = 0.40 mds. or 24%

Unfermented Dacca compost : increase = 0.27 mds. or 16%

In the latter case part of the nitrogen was as soluble artificial, while nitrogen in *Phutuka* leaf has previously been seen to be readily available : the presence of relatively heavy wood does not appear to interfere with the action of these, although the ratio of organic matter to nitrogen was very high.

All these sets of plots will be plucked without further manuring during 1937, except that the fermented Dacca compost will be applied in February.

Trials similar to these will be in progress, in 1937, on five commercial gardens in the Surma Valley and the Dooars. Results from all these will test the two widely advertised claims made, without any evidence, (1) that fermented organic composts possess very high efficiency, compared to artificials, and (2) that the

fermentation must take place before the material is applied to the soil.

It is to be expected that the artificial will establish an early lead. The main interest of these trials will be the comparisons after ten years and more.

Leguminous Plants among Tea.

1. Comparison of cowpeas, boga medeloa (*Tephrosia Candida*) and sulphate of ammonia against no treatment.

All plots received in March 1934 a basal dressing supplying 40 lbs. phosphoric acid as basic slag and 40 lbs. potash as sulphate of potash. Without this dressing cowpeas yield a miserable crop at Borbhetta, such that it would have been useless to test its action. With it, normally good crops (in each year 3 tons green stuff per acre) were grown. The dressing also improves the growth of boga medeloa, though not so greatly. The dressing has no action on tea at Borbhetta.

The treatments compared are :—

1. No manure.
2. Cowpeas sown in March and hoed in early June; in 1934 and again in 1935. No treatment in 1936.
3. Boga medeloa sown in March 1934 in hedges between alternate lines of tea, kept rigorously lopped, reducing the hedges to bare sticks 5 feet high, once in 1934, three times in 1935, and once in early May 1936. After this last lopping the sticks and bigger roots were removed. No other treatment in 1936.
4. 145 lbs. sulphate of ammonia per acre, in March 1934, and again in March 1935 (total in 2 years 290 lbs.). No treatment in 1936.

Crops in mds. per acre have been :—

	1934	1935	1936	total in 3 years	gain due to treatment	total lbs. nitrogen buried.
No nitrogen	9·21	7·90	5·91	23·02	...	nil.
Cowpeas	9·23	7·97	6·10	23·30	0·28	58
Boga medeloa	8·56	8·20	8·85	25·61	2·59	189
Sulphate of ammonia	9·82	9·56	6·68	26·06	3·04	60
Difference required for significance:—	0·32	0·37	0·64			

The cowpeas have shown no effect of any significance at all. The two crops contained 58 lbs. nitrogen per acre. Presumably this nitrogen was merely taken from the soil to which it was returned, and represents no gain. This may be due to one or both of two causes. They were growing at a season when the soil is naturally rich in available nitrogen when clean, and they were hoed in before they reached maturity. The boga medeloa produced a significant loss of crop in the first year, and a small gain, (not statistically significant) in the second-year. Over the two years crops were equal, within experimental error, to those from the untreated plots. In the two years 189 lbs. nitrogen per acre had been buried as loppings. Soon after the boga medeloa was removed, the tea in all plots on which boga medeloa had been growing showed wonderful growth and gave 50% more tea during the season than the untreated plots. Further residual good effect is expected to show from the boga medeloa in 1937, and perhaps in later years, so that among this poor tea, boga medeloa probably will show better results than sulphate of ammonia totalling 60 lbs. nitrogen per acre and not repeated. The sulphate of ammonia is not expected to show much more residual effect, though the residual effect in 1936, of the small doses of 1934 and 1935, is significant.

2. Effect of boga medeloa, lopped and unlopped, with and without sulphate of ammonia.

Leguminous plants like boga medeloa (*Tephrosia Candida*) are beneficial to the tea among which they grow, by reason of the

nodule-bacteria living on their roots which have the power of fixing nitrogen from the atmosphere. According to one theory, nitrogen compounds diffuse into the soil from the legume roots, and are used by roots of neighbouring non-leguminous plants. The result of the experiment just quoted affords no support to this theory. In that case the boga medeloa was grown as thick hedges, and possibly may have occupied the soil too densely with its roots. Also the boga medeloa was closely lopped, and lopping might interfere with the plant's normal functions.

In the present experiment, the boga medeloa was thinned out, soon after sowing, till only a single plant remained between every four bushes in alternate lines. That is, the boga medeloa was planted as single plants 4¼ by 8½ feet square, the tea being 4¼′ × 4¼′ square.

It will be observed from the results below, that so far from increasing tea crop, even this light stand of boga medeloa reduces tea crop significantly, whether lopped or not lopped. Lopping, so far, has not amounted to much.

The failure of the cowpeas in the last-quoted experiment may be due to the fact they occupied the soil at a time when it was rich in available nitrogen. This present experiment will try a legume both in poor soil, and in a soil kept rich by manuring.

	Mds. tea per acre, 1936.			
	Means of 6 plots			means of 18 plots.
	No boga medeloa	With boga medeloa		
		Lopped	Unlopped	
with 300 lbs. per acre sulphate of ammonia	10·35	9·64	9·53	9·84
no manure	8·03	7·63	7·41	7·69
mean of 12 plots ...	9·19	8·64	8·47	

Difference required for significance between means of 6 plots 0·559 mds.
between means of 12 0·395 „
„ „ „ 18 0·323 „

It will be observed that there is, so far, no "interaction" between the effects of boga medeloa and of sulphate of ammonia. The depression of tea crop by the boga medeloa is, within experimental error, the same in the presence of sulphate of ammonia as in its absence.

This question of the interaction is the chief question which this experiment is designed to answer. When the boga medeloa produces benefit to the tea, as it is expected to do eventually, will this benefit be as great in a soil well supplied with available nitrogen as in soil with as little available nitrogen as is normal on a soil of this nature when unmanured?

It will be decided also whether it is better to force growth of boga medeloa leaf, for burial, by lopping the plants; or whether better results accrue from leaving the leaf to fall naturally.

Under the latter system, the boga medeloa plants will have the longer life, but it may pay to re-sow every two or three years.

Application of Manures.

(*a*). Application of soluble manure to clean soil in March with no cultivation to cover it.

(*b*). Autumn against spring manuring.
2nd year of treatment.

Manure applied annually :—

		lbs. per acre.
Sulphate of ammonia	...	300
Ordinary superphosphate	...	150
Muriate of potash	...	40

	Mds. tea per acre.						
	1934	1935		1936			Total 26 months
	Oct. 20th to Nov. 31st.	To end June	July to end Nov.	to end June	July to end Oct.	Nov-ember	
Manure broadcast on March 25th, 1935 and 1936, not cultivated till mid-May ...	2·22	2·44	11·30	1·32	10·58	1·00	28·86
Manure broadcast on March 25th,1935, and 1936, and covered at once by light hoe ...	2·24	2·40	11·21	1·31	10·43	0·93	28·52
Manure broadcast Oct. 6th 1934, Oct. 25th 1935, Oct. 5th 1936 and covered by light hoe ...	2·81	2·61	10·68	1·48	10·25	1·20	29·03
No manure ...	2·29	1·94	8·33	1·09	7·67	0·77	22·09
Difference required for significance	0·17	0·18	0·88	0·17	0·90	0·18	2·20

(*a*). There has been no loss from failure to cultivate after application of a soluble manure to moist soil on flat land.

(*b*). The October manuring shows a gain in crop at the end of the same season when rain is favourable. In 1935 there was no end of season gain when the soil remained dry.

The June crops are higher from autumn than from spring manuring by an amount which is statistically significant but is of no practical importance.

The hope that autumn manuring might do something to minimise the effect of spring droughts therefore ends in disappointment. Comparison of crops to end of June in 1935 and 1936 respectively indicates the severity of the 1936 spring drought. There is however no objection to the autumn manuring except that it uses labour at a time when it cannot well be spared.

Potash and Phosphoric Acid.

(1). Experiments started in 1931 :—

1 set of 8 plots receives no manure.

15 sets of 8 plots each receives annually 40 lbs. nitrogen per acre, together with the mixtures supplying potash and phosphoric acid shown below, with the following resulting crops in mds. tea per acre in 1936, the 7th year of continuous similar treatment.

		Mds. tea per acre, 1936.				
		lbs. potash per acre				Mean
		0	15	30	60	
Phosphoric	0	10·07	—	10·26	11·49	10·61
Acid	15	10·10	11·55	10·11	11·64	10·85
lbs.	30	10·80	11·88	10·69	12·12	11·37
Per acre	60	11·07	11·95	11·03	12·67	11·68
Mean	...	10·51	11·79	10·52	11·98	

Between yields of individual treatments (means of 8 plots) a difference of 1.10 mds. is required for significance. Between means of 32 plots a difference of 0.55 is significant.

Phosphoric acid.

The difference between 0 or 15 lbs. phosphoric acid per acre, and 60 lbs. is significant, but not the difference between 0 and 15, 15 and 30, or 30 and 60.

It will be observed that mean yields increase as the phosphoric acid is increased, and this "regression" is statistically significant.

Phosphoric acid, therefore, has this year made a definite difference for the better in crop. The difference however is very small. It may be assessed at about 1 md. tea per about 45 lbs. phosphoric acid, which could be bought, in available form, most cheaply as 1 cwt. concentrated superphosphate costing, in Calcutta, Rs. 7-4.

The sixteenth set of plots receiving no manure produces 6.31 mds. tea per acre. 40 lbs. nitrogen per acre alone, without potash or phosphoric acid, increased this yield to 10.07, a difference of 3.76 mds. tea. This difference is produced by the use of 195 lbs. sulphate of ammonia annually, costing in Calcutta, Rs. 10-3, or Rs. 2-11-4 per md. of tea.

To maintain or increase tea crop, therefore, it is very much cheaper to increase the dressing of nitrogen than to use phosphoric acid in addition to nitrogen, even in the seventh year of continuous application.

Potash.

In the case of potash we see the apparent anomaly that—

15 lbs. and 60 lbs. potash per acre increases crop.
30 lbs. potash per acre does not.

This is the result of being obliged to use the same set of plots for two purposes: in this case, measurement both of yield and of market value of the product.

Each week during the season, the 4 sets of plots receiving no potash, and the 4 sets of plots receiving 30 lbs. potash were plucked separately for separate manufacture. In order to keep conditions as much alike as possible for manufacture, these plots were plucked first and the leaf taken away for withering. This plucking occupied the whole morning.

The remaining plots—

1 set receiving no manure.

3 sets receiving 15 lbs. potash per acre.

4 sets receiving 60 lbs. potash per acre.

were plucked in the afternoon.

The difference between afternoon and morning plucking was noticed early in the season, but the closest supervision in the field could not produce quite the same fineness of plucking in the afternoon as in the morning. It is however believed that the difference was not only due to difference in fineness of plucking, but largely to a real increase in weight of leaf of the same fineness after a morning in the sun.

When leaf is not required for manufacture plucking is by blocks, each block containing all the treatments, and the difficulty experienced in 1936, will not recur in future years.

Regarding the effect of potash, we must base conclusions for 1936 on the following facts :—

Plucked in the morning—

No potash	...	10.51 mds. tea per acre.
30 lbs. potash per acre	...	10.52 ,, ,, ,, ,,

Plucked in the afternoon—

15 lbs. potash per acre	...	11.79 mds. tea per acre.
60 lbs. ,, ,, ,,	...	11.98 ,, ,, ,, ,,

In neither case is there any approach to significance due to increase in the supply of potash, and it must be concluded that potash has exercised no influence on crop.

That there should be a difference of 1.4 mds. tea per acre due to afternoon against morning plucking is certainly suprising, but this is the only possible explanation of the results obtained.

Quality.

Results of the weekly manufactures from these plots are :—

1. A very slight but significant gain in quality from the use of phosphoric acid.
2. A very slight but significant loss in quality from the use of potash.

Averages of 6 London Brokers found, over the whole season, no significant difference due either to potash, or to phosphoric acid. Over the earlier teas only, a significant loss in quality due to potash was found, but no difference due to phosphoric acid.

It is concluded that the cost of the potash is much better avoided; while the use of phosphoric acid is not generally likely to prove profitable, although it may improve both yield and quality slightly.

As far as yield is concerned these conclusions regarding the inefficiency of potash or phosphoric acid for tea are confirmed wherever experiment has been made, at Tulsipara in the Dooars, at Behora on heavy red soil in the Dhunseri district of Assam, at Seajuli on a coarse sand on the North Bank of Assam, and at St. Coombs in Ceylon.

In 1937 experiments on the subject will commence on 18 other gardens in North-East India, preliminary records having been kept in 1936 when the plots to be used in 1937 were all untreated.

(2). The first trial on this subject commenced in 1922 using 4 replications only without preliminary records. The plots are uneven. Error has always been high, and in 1936 was increased by uneven effects of hail which was very bad on these plots, so that they produced 3 mds. per acre less than in 1935.

The plots are carried on in the hope that long continued manuring with heavy doses of nitrogen without potash or phosphoric acid may cause some visible effect on the bushes to show up, eventually.

All plots received no nitrogen 1922 to 1925 inclusive—

30 lbs. nitrogen per acre 1926 to 1933 inclusive.

120 lbs. nitrogen per acre 1934 to 1936 inclusive.

Results in 1936 have been :—

	With lime	Without lime	Means of 8 plots.
No potash or phosphoric acid ...	10·73	10·47	10·60
Potash only	10·08	11·28	10·78
Phosphoric acid only ...	10·64	11·45	11·04
Potash and phosphoric acid ...	11·84	11·37	11·60
Means of 16 plots ...	10·82	11·14	

None of the differences approach statistical significance. The differences due to potash, phosphoric acid, or both together are certainly small, if they exist at all. Plots which have never received any manure except nitrogen, so far appear healthy and exhibit normal growth.

Lime and Soil acidity.

As indicated by the result of the experiment last quoted, small dressings of lime make very little difference to the crop of tea.

An accurate experiment (9 replications) yields similar results.

In 1932 the effects of 560 lbs. pure lime per acre (1,000 lbs. locally purchased slaked lime) and 400 lbs. sulphur per acre, were tried respectively against no treatment.

	mds. tea per acre, 1936.
Sulphur	14.30
Lime	13.68
No treatment	13·55

The differences are not significant.

A difference of 1 md. tea per acre would be accounted significant and it may be suspected that the sulphur still exercises a small good effect.

400 lbs. sulphate of ammonia per acre have been applied in the past 7 years, and there are now only slight differences in soil acidity.

The bad effect of sufficient lime to bring soil reaction close to neutrality (absence of acidity), and the failure to harm tea by sufficient dressings of sulphur to produce very high acidity are demonstrated on a number of plots too small to afford accurate measurements of yield.

The following result is reported by Mr. Shove, Scientific Officer to the Doom Dooma Tea Company and Associated gardens.

An experiment commenced at Tara T. E. in 1936 shows no significant difference in tea crop for the use of either 2,000 lbs. slaked lime or 800 lbs. sulphur per acre in the first year, although soil acidity has greatly changed within one year fairly evenly to a depth of 2½ feet.

	pH of soil : water suspension.	pH of neutral salt extract.	Hopkins acidity.
2000 lbs. slaked lime per acre ...	5·61	5·10	238
No treatment	5·38	4·48	550
800 lbs. sulphur per acre ...	5·16	4·43	772
Difference required for significance	0·14	0·15	191

Experiments on Estates.

Halem Tea Estate.

Comparison between effects of annual dressings of cattle manure and of artificial mixture over four consecutive years.

	Mds. tea per acre				Total in 4 years	Gain from manure
	1933	1934	1935	1936		
340 lbs. artificial mixture...	10·52	11·53	13·87	13·22	49·14	5·40
16000 lbs. cattle manure ...	10·46	11·17	13·39	12·89	47·91	4·17
No manure	9·83	10·30	12·28	11·33	43·74	—
Difference required for significance	0·72	0·69	0·66	0·62	2·15	2·15

The unmanured soil is still so good that the increase due to manuring, though quite definite, is relatively small.

While both manures yield significantly more than no manure, the apparent difference in favour of the artificial against the cattle manure is not shown as significant, but if there is anything in it the artificial is indicated as the more efficient.

In each year a number of samples of the cattle manure has been analysed and a just estimate of the food stuffs supplied so obtained. The cattle manure used has been very dry and above the normal average of richness.

The quantities applied as cattle manure per acre have been :—

	lbs. per acre				Total in 4 years	average lbs. annually per acre
	1933	1934	1935	1936		
Nitrogen ...	103	117	92	85	397	99
Phosphoric acid ...	82	53	43	64	242	60
Potash ...	62	66	55	78	261	65
Dry organic matter ...	2500	2488	1843	1795	8626	2156

The artificial has supplied each year, per acre :—

40 lbs. nitrogen.
20 lbs. phosphoric acid.
20 lbs. potash.

The artificial is clearly the more efficient per unit of nitrogen and there is no sign of benefit from the heavy bulk of "humus" supplied by the cattle manure.

160 lbs. nitrogen as artificial have given an increase of	...	432	lbs. tea.
or per lb. of nitrogen	...	2.7	,, ,,
397 lbs. nitrogen as cattle manure have given ...	...	333.6	,, ,,
or per lb. of nitrogen ...	...	0.84	,, ,,

To-date the cattle manure has about one-third of the efficiency of the artificial per unit of nitrogen. This is on a coarsely sandy soil, where bulky manures might be thought likely to prove advantageous.

At Halem only the costs of carting from the pits to the tea, and of carrying the manure into the section and spreading it, are charged to the manure. The cost of collection is debited to the necessary cleaning of lines.

In this case, then, the manure itself may be looked upon as a waste product, the application of which as manure must pay in the general case. If all costs had to be charged to the manure, there would be little hope of profit from the use of any bulky organic manure compared to the use of an artificial.

Where, as at Halem, the bulk of the cost of the humus manure is chargeable to some other necessary work, the use of such waste material may show very profitable returns. At Halem, very accurate accounts of all costs have been kept, with the following results :—

	Rs.	As.	P.
Cattle manure, cost of carting, carrying and spreading 200 mds. ...	9	8	0

		Rs.	As.	P.
Artificial, total cost including freight and application		19	13	6
Rs. 38/- on cattle manure gave ...	333.6 lbs. tea.			
Re. 1/- on cattle manure gave ...	8.8 ,, ,,			
Rs. 78/6/- on artificial gave ...	432 ,, ,,			
Re. 1/- on artificial gave ...	5·5 ,, ,,			

and the cattle manure wins, on comparison for price, where it can be applied so cheaply.

Seajuli Tea Estate.

An experiment, on a Latin Square design, with preliminary yields in 1935, was carried out by the Manager, with the following results :—

Manure per acre	Mds. tea per acre 1936
nil	10·20
300 lbs. sulphate of ammonia (nitrogen only) ...	13·31
300 lbs. sulphate of ammonia ... ... 200 lbs. ordy. superphosphate (nitrogen and phosphoric acid)	12·61
300 lbs. sulphate of ammonia ... ... 80 lbs. sulphate of potash (nitrogen and potash) ...	12·75
300 lbs. sulphate of ammonia ... ... 80 lbs. sulphate of potash ... ... 200 ,, ordy. superphosphate (nitrogen potash and phosphoric acid)	13·14
Difference required for significance ...	0·96

There is no sign of benefit from potash or phosphoric acid, but the use of nitrogen alone shows a very significant gain.

This also is a coarse sandy soil.

TULSIPARA EXPERIMENTAL PLOTS

Following a severe early spring drought, the season at Tulsipara was, in contrast to that at Borbhetta, a good one, and crops generally are ahead of 1935 throughout the experimental area. Red spider and other diseases were practically non-existent and experiments on spraying had for this reason to be postponed for more favourable conditions (from point of view of these experiments).

Among the more striking of the results obtained in 1936 are :—

(1). The remarkable success of unpruned tea. The results are discussed in detail in the section dealing with the pruning experiments. Such success is difficult to explain, since though red spider was absent this year, it was also very little in evidence in 1934 when the tea was last unpruned and when much smaller increases were obtained. Certainly the early spring drought in 1936, which almost completely defoliated the unpruned tea, seems to have had no adverse effect on it.

(2). The slight, but nevertheless significant, good effect of sulphur on soil already considered sufficiently acid for tea. The value of the increase of about ½ md. tea per acre is very far short of the cost of the sulphur (400 lbs. per acre), which was in the region of Rs. 40/- per acre, but it remains to be seen (*a*) whether such increase is maintained without further addition of sulphur and (*b*) whether, in the event of severe red spider attack, the sulphur-treated plots remain freer than untreated plots, with a resulting further increase in crop.

Individual experiments are considered in detail below.

Pruning.

There are nine pruning systems being tried, each system repeated on seven plots. Of these nine systems, four are systems of pruning performed annually, four are the same systems, but are performed only every two years, the tea being left unpruned in the intermediate year, while the ninth system is one in which the tea is top pruned with light cleaning out, at intervals of 18 months. The four systems of pruning done at yearly intervals are :—

1. Top pruning in December with light cleaning out of banjhi twigs, dead wood, and very weak or diseased wood.

2. Top pruning in December with no cleaning out, *i.e.*, simply a "cut-across".

3. As in the case of 1, but initially (1930) bushes were stick pruned.

4. Top pruned in April (after the first flush has been plucked) with light cleaning out.

5, 6, 7 and 8 have respectively the same treatment as 1, 2, 3 and 4, but only in alternate years. The unpruned seasons were 1932, 1934 and 1936.

In series 9 the 18-month interval pruning was done in June 1931, December 1932, June 1934 and December 1935.

The yields for all nine systems of pruning are given below for the past 5 years.

	mds. tea per acre					Total for 5 years
	1932	1933	1934	1935	1936	
Pruned annually.						
1. In December without cleaning out ...	6·88	9·96	10·74	9·04	11·90	48·62
2. In December with light cleaning out	7·27	11·26	10·94	10·28	12·32	52·07
3. In December: (stick pruned in 1930; since lightly cleaned out) ...	5·80	10·16	9·51	10 28	12·08	47·83
4. In mid. April; with light cleaning out	5·39	9·82	8·45	7·34	9·13	40·13
Pruned in alternate years.						
5. As for 1, but in December 1930, 1932, 1934 and 1936 ...	9·23	10·00	15·57	9·09	19·97	63·86
6. As for 2, but in December 1930, 1932, 1934 and 1936 ...	8·49	10·93	13·33	10·36	20·08	63·19
7. As for 3, but in December 1930 (stick pruned); 1932, 1934 & 1936 (light cleaned) ...	7·41	9·55	12·93	9·54	19·63	59·06
8. As for 4, but in April 1930, 1932 and 1934. ...	10·37	9·62	15·39	7·86	19·95	63·19
Pruned at 18-month intervals.						
9. Pruned with light clean-out in June 1931, Dec. 1932, June 1934 and Dec. 1935 ...	9·33	11·22	7·37	15·25	12·62	55·79
Difference required for significance ...	...	1·09	1·30	1·48	2·21	...
Difference required for significance between annually pruned plots only	...	...	...	...	1·09	...

The success of unpruned tea in the Dooars, is borne out by the results of the 1936 season. Yields for the four sets of pruned and unpruned tea are given for ease of comparison in the table below :—

Pruning treatment	Mds. tea per acre	
	Pruned in 1936	Unpruned in 1936.
Pruned in December with light cleaning out ...	12·32	20·08
„ „ „ „ no cleaning out ...	11·90	19·97
„ „ „ „ light cleaning out but stick pruned in Dec. 1930 ...	12·98	19·63
„ „ April with light cleaning out ...	9·13	19·95
Average ...	11·36	19·91
Significant difference between pruned and unpruned ...	= 1·10 mds.	

As may be seen from the table of yields for the past 6 years the increase from unpruned tea has previously been much smaller. All plots have much improved since the last unpruned year, 1934, but even so, the huge increase in yield off unpruned tea in 1936 is difficult to account for.

Cleaning out has produced a small increase in crop, (actually not significant this year) on pruned tea and no appreciable effect on unpruned tea.

Significant loss in crop occurs in the same year from pruning during the growing season, the drop being over 3 mds. compared with similar pruning in December. The effect of pruning in April 1935 as compared with the earlier December pruning, on yield of tea left unpruned the following season (1936) is negligible.

The bushes stick pruned in 1930 have now recovered and are yielding the same as the bushes which were normally cleaned out in 1930. These bushes lost much crop in the 4 years following the drastic pruning treatment and it will doubtless be a long time before they make up this loss, if ever. The cost of the

stick pruning was of course very much higher than that of normal cleaning out, and it would so far appear that on this tea at any rate, money thus spent only caused loss of crop.

Pruning at 18-month intervals.

Series 9 was pruned in June 1931, and left unpruned for the 1933 season, when it gave about the same crop as series 6 which had been last pruned in December 1930, which was also cleaned out when pruned. In 1933, after both of these series had been pruned the previous December, they both gave about the same crop as the annually pruned series 2. In 1934, series 9 was pruned in June and lost crop considerably, but in 1935, its unpruned year it gave 5 mds. per acre more than the pruned tea. Pruning on 18-month old wood in December 1935 has again given in 1936, the same crop as the annually pruned tea. It appears to make no difference to crop in the following year whether the top pruning is on 12, 18 or 24-month old wood. The end of the 1937 season will complete the first 6-year cycle, when yields for the three intervals of pruning can be compared.

PLUCKING.

As in the case of the pruning experiments, there are 9 treatments, each replicated 7 times. Six of the treatments are concerned with the amount of leaf left on the bush, plucking in each case being at weekly intervals. The 1935 and 1936 yields are given below :—

Weekly plucking.

Plot-set	Style of plucking.	Yields mds. tea per acre	
		1935.	1936.
1	6″ initial growth and then to janam ...	12·26	13·01
2	8″ „ „ „ „ „ „ ...	11·11	12·66
3	6″ „ „ „ a big leaf once only ...	11·95	12·73
4	8″ „ „ „ „ „ „ ...	10·74	11·92
5	6″ „ „ „ 1 big leaf till mid August ...	10·33	12·25
6	4″ „ „ „ „ „ throughout season	8·67	10·23
	Difference required for significance ...	0·92	1·05

This year, crops from bushes plucked at 6″ and 8″ initial growth and to the janam are the same within the limits of error. Last year the difference in favour of plucking to the shorter initial growth was just significant. The effect of leaving a big leaf once only, compared with plucking to the janam is also not significant. Last year there was no significant difference from leaving a leaf and the strengthening effect on the bush of leaving a leaf is thus further confirmed. In early years, losses from more sparing plucking were significant, and there is still, after 6 years no sign of gain from more sparing plucking.

	Mds. tea per acre.		
	Plucked to janam	Plucked leaving one big leaf	Average of 14 plots
Initial height 6″	13·01	12·73	12·87
,, ,, 8″	12·66	11·92	12·29
Average of 14 plots ...	12·83	12·32	

Significant difference for average of 14 plots = 0·73 mds.

Effect of varying intervals between plucking.

All plucked 6″ to janam.

	Mds. tea per acre	
	1935	1936
7 days with breaking back	12·26	13·01
10 days ,, ,, ,, ...	12·37	13·89
10 days without ,, ,, ...	11·83	13·22
14 days ,, ,, ,, ...	1073.	11·02
Significant difference ...	0·92	1·05

As in 1935 it makes no significant difference to crop whether plucking is 7 or 10 days, or whether breaking back is done or not. By extending the interval to 14 days a significant loss in crop results, and the leaf taken is, in spite of all possible care, inevitably coarser from the plucking at the longer interval.

MANURING.

(1). *Trial of artificial manures.*

As in the case of all areas generally at Tulsipara, this year's yields from the manuring plots are up on 1935 yields. The unmanured plots are 1⅓ mds. up; the plots getting 40 lbs. nitrogen are 2 mds. up; and those getting 80 lbs. nitrogen are 2⅓ mds. up on the previous year. The results from potash and phosphoric acid manures are confusing. Either mineral gives (in 1936 for the first time) significant increase over the yield from nitrogen alone, which is not the case when both minerals are applied together.

	Mds. tea per acre		
	Manures applied to supply per acre		Average for phosphoric acid 14 plots
	No potash	40 lbs. potash	
No phosphoric acid ...	13·57	14·34	13·95
40 lbs. „ „ per acre	14·46	13·93	14·20
Average for potash :— 14 plots ...	14·01	14·13	

Significant difference for average of 7 plots ... ... = 0.73 mds.

Significant difference for average of 14 plots ... ... = 0.51 „

With 80 lbs. nitrogen and no phosphoric acid, large doses of potash still have no effect.

Plot set.	lbs. per acre annually			Crop in mds. tea per acre		
	Nitrogen	Phos: acid	Potash	1935	1936	
1.	0	0	0	10·28	11·59	Average for
2.	40	0	0	12·04	13·57	40 lbs.
3.	40	0	40	12·06	14·34	nitrogen =
4.	40	0	80	12·33	14·44	14·15
5.	40	40	0	12·04	14·46	
6.	40	40	40	12·02	13·93	Average for
7.	80	0	0	13·09	15·65	80 lbs.
8.	80	0	80	13·03	15·30	nitrogen =
9.	80	0	160	13·40	15·41	15·45
	Difference required for significance ...			0·98	0·73	

The effect of nitrogen is significant, 40 lbs. per acre annually has given in the 6th year an average increase of 2.56 mds. tea per acre over no manure while the increase for 80 lbs. nitrogen per acre is 3.86 mds. The extra 40 lbs. nitrogen has produced only 1.30 mds. tea in excess of the first 40 lbs. nitrogen. There is thus a 22% increase in crop from 40 lbs. nitrogen, and a 33⅓% increase from 80 lbs. nitrogen in the 6th year of continuous annual application.

(2). *Trial of Cattle manure against artificial.*

There are three treatments, each replicated only 3 times. The treatments are :—

1. Mixture of soluble artificial providing 40 lbs. each of nitrogen, phosphoric acid and potash per acre.
2. Cattle manure at 5 tons per acre (about 100 lbs. nitrogen, 60 lbs. phosphoric acid and 50 lbs. potash).
3. No manure.

The yields for 1936 are :—

		mds. tea per acre.
1.	Artificial	13.65
2.	Cattle manure	12.12
3.	No manure	10.47

Difference required for significance = 3.82.

This year the difference between artificial and cattle manure, and between these and no manure, do not actually prove statistically significant, though there is a 3¼ mds. difference between the soluble artificial and no manure. There is no doubt however that the manures are having effect. What has happened is that this year, one of the cattle manure plots has for some reason given a smaller yield than it did in 1935, whereas all other plots, including the unmanured, have given increased yields. This discrepancy has a very serious effect on the statistical analysis, when there are only 3 repeats of each treatment, the significant difference required being enormously increased. This experiment illustrates the inadequacy of such a small number of replicates as 3. This was, in fact, realised when the experiment was commenced, but it was designed to use up an odd set of nine plots and is intended more for demonstration purposes than as an accurate test of manurial effects.

(3). *Comparison of the effects of sulphate of ammonia and sulphur respectively against no manure.*

Three treatments, 10 times replicated. First year of application.

	mds. tea per acre,
	1936.
No manure	10.52
400 lbs. sulphur	11.01
400 lbs. sulphate of ammonia ...	12.07

Significant difference 0.45 mds. tea per acre.

A striking comparison in accuracy is provided by comparing the results of this experiment with the foregoing one. Here there are 10 replicated plots and the accuracy of the average yields for the three treatments is such that a difference of only 0.45 mds. is required for significance (as compared with 3¾ mds. required for difference in the cattle manure-sulphate of ammonia experiment).

Sulphur has shown a slight but significantly good effect, and sulphate of ammonia a very big increase over the unmanured plots. The improvement due to sulphur is all the more striking since the soil on which these plots are located, is considered quite sufficiently acid for tea, the pH varying between 5.0 to 5.6.

(4). *Temporary depressing effect of sulphate of ammonia.*

It is of great interest to observe that the application of sulphate of ammonia in the above experiment was followed by a short period of depression of crop.

The manure was applied on May 26th. Crops taken on May 29th were not affected, but loss of crop was definite on June 5th, 12th and 19th from those plots on which sulphate of ammonia had been applied.

	lbs. leaf per 2000 bushes								
	To end May	June				July			
		5	12	19	26	3	10	17	24
Sulphate of ammonia	67	27	55	64	60	93	87	118	135
No manure ...	67	31	66	72	57	66	70	100	122
Sulphur ...	67	30	64	69	57	72	70	106	128

The sums of the yields for June 5th, 12th and 19th, are :—

Sulphate of ammonia	...	146 lbs.
No manure ...	....	173 ,,
Sulphur ...	...	163 ,,
Difference required for significance ...	=	14 ,,

The loss for the 3 weeks following the application of sulphate of ammonia is significant. On the 3rd July, or 38 days after application the good effect of the sulphate of ammonia is very marked and this good effect was maintained every week for the remainder of the season

CULTIVATION.

(1). *Deep cultivation in the cold weather.*

(2). *Light cultivation; different methods of suppressing jungle in the rains.*

8 treatments; 5 times replicated; sixth year of similar treatment.

Yields in mds. tea per acre, 1936.

Light cultivation	With deep hoe in January.	Without any cold weather cultivation.	Mean of 10 plots.
1. 8 rounds light hoe annually	9·07	7·94	8·50
2. 4 „ „ „ „ ...	7·62	7·03	7·32
3. 8 „ "cheeling" ...	8·92	7·83	8·37
4. 8 „ sickling ...	6·98	7·56	7·27
Mean of 20 plots ...	8·15	7·59	

Significant difference between means of 5 plots ... ... = 1.28 mds.

Significant difference between means of 10 plots ... ... = 0.91 „

Significant difference between means of 20 plots ... ... = 0.64 „

(1). *Deep Cultivation.*

Both the 8 rounds hoeing and the 8 rounds cheeling may be considered practically to suppress weeds during the growing season.

If only the efficient forms of light cultivation be considered it is seen that the cold weather hoe has produced a good effect.

	With deep hoe.	Without deep hoe.
Cheeled 8 times ...	8·92	7·83
Hoed 8 times	9·07	7·94
Mean of 10 plots ...	9·00	7·89

The difference in favour of the deep hoe of 1.11 mds. is significant.

If only the inefficient forms of light cultivation be considered no good effect appears from the deep hoe.

	With deep hoe.	Without deep hoe.
Hoed 4 Times	7·62	7·03
Sickled only	6·98	7·56
Mean of 10 plots ...	7·30	7·23

It is probable that the cold weather hoe did good on the efficiently cultivated plots by keeping them cleaner of weeds between the last light hoe of October and the first light hoe of March.

On the inefficiently cultivated plots the production of a loose tilth by the deep hoe encourages the germination and growth of weeds compared to what is possible on hard undisturbed soil.

The freedom from weeds of those sickled plots which are not deep hoed compared to the sickled plots which are deep hoed is very striking to the eye in April. In this case the close occupation of the surface soil by the roots of tea, when undisturbed, probably also assists in the suppression of weeds.

(2). *Light Cultivation.*

The significant difference required for average of 10 plots is 0.90 mds. tea per acre. Hoeing and cheeling produce the same crop for the same number of rounds of each, indicating that no extra benefit is derived from soil stirring in addition to weed suppression.

Significant loss of crop results from reducing the rounds of light cultivation from 8 to 4. This involves extending the period between hoeing rounds from one to two months during the 8 months period of maximum growth of tea and jungle. Plots getting light cultivation monthly have seldom any jungle growth to reduce the concentration of soluble nitrogen in the soil, while those hoed at two monthly intervals carry a considerable jungle growth for more than half of the plucking season. On the deep hoed plots, sickling during the rains gives significantly less crop than that of the plots getting efficient jungle suppression in the rains. On plots not deep hoed in the cold weather, sickling during the rains has not lowered the crop significantly as compared with plots getting any form of rains cultivation.

(3). *Trenching.*

This experiment was started in 1934 to test the effect if any, of trenching (deep and shallow) with and without burial of cattle manure. As previously reported, no significant effect has so far been obtained from the trenching or from the application of cattle manure (at the rate of 10 tons per acre) which was done in the 1933-34 cold weather. Again in 1936 no significant differences show up due to trenching or to cattle manure. The average yield of the area of tea on which these plots are laid out was 11¼ mds. tea per acre in 1936.

SPRAYING.

Red spider and other disease being practically non-existent during 1936, no experiments could be made on this subject.

It is of passing interest to observe that the 9 spraying treatments intended had been designed each to be applied to 7 plots of 200 bushes each, from which yields in 1935 were known.

The yields per plot-set of 7 plots in 1936 when all were actually under the same treatment were :—

2,142 lbs. leaf.
2,115 ,, ,,
2,104 ,, ,,
2,087 ,, ,,
2,077 ,, ,,
2,058 ,, ,,
2,036 ,, ,,
2,011 ,, ,,
1,999 ,, ,,

The sums of the yields of all these 9 plot-sets had been practically the same in 1935, yet in 1936 the best set gives 143 lbs. or 7% more crop than the worst plot-set. The need for a valid estimate of error is thus indicated. It is hoped that there may be sufficient red spider to make trials of spraying possible on these plots in 1937.

INDEX

TO

AGRICULTURAL REPORT, 1936.

A.

B.

C.

C.—(*continued.*)

D.

F.

G.

H.

I.

J.

PAGE.

L.

M.

N.

O.

INDEX

S.—(*continued.*)

T.

U.

W.

Y.